BIONOMICS AND CHEMICAL CONTROL OF FREE-TAILED HOUSE BATS (*Molossus*) IN TRINIDAD

SPECIAL SCIENTIFIC REPORT: WILDLIFE No. 53

TRINIDAD AND TOBAGO
MINISTRY OF AGRICULTURE, LANDS, AND FISHERIES
DEPARTMENT OF AGRICULTURE

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

BIONOMICS AND CHEMICAL CONTROL OF FREE-TAILED HOUSE BATS (*Molossus*) IN TRINIDAD

by

Arthur M. Greenhall, Zoologist

and

Gerald Stell, Entomologist

Department of Agriculture, Trinidad and Tobago
The West Indies

Published by

U. S. Department of the Interior
Fish and Wildlife Service
Bureau of Sport Fisheries and Wildlife

Fish and Wildlife Service
Special Scientific Report--Wildlife No. 53

Washington, D. C. - August 1960

PREFACE

This is a cooperative venture between the Trinidad and Tobago Department of Agriculture and the United States Fish and Wildlife Service. The project was suggested by the Bureau of Sport Fisheries and Wildlife to the senior author who has been associated with them for a number of years and still continues to cooperate through his curatorship with the Royal Victoria Institute Museum, Trinidad.

The problem of bats infesting dwelling houses is almost worldwide and these studies have a direct application to this problem in the Southern United States and Puerto Rico, as well as any area where free-tailed molossid bats are found. The work was conducted in Trinidad rather than in the United States of America because the problem is ever acutely present in Trinidad.

Arthur M. Greenhall is Curator of the Royal Victoria Institute Museum, Trinidad, West Indies. Gerald Stell, formerly of the Department of Agriculture, Trinidad and Tobago, is now Chief Plant Protection Officer of the Department of Agriculture, Jamaica, West Indies.

TABLE OF CONTENTS

ABSTRACT

Since the construction of buildings by man, house bats infesting roof spaces have presented a serious nuisance, constituting health and economic problems throughout the world, especially where there is no proper bat-proofing in the initial construction. In Trinidad this problem is acute. Previous studies on control measures are evaluated. Experiments carried out used locally available chlorinated hydrocarbon insecticides. Results indicate that where a repellent was required, B.H.C. was preferred and where a toxicant was more desirable, D.D.T. Either of these insecticides resulted in the removal of house bats from roof spaces in three to four weeks and D.D.T. had a residual effectiveness of at least one year. Methods of insecticide application and assessment of bat populations are discussed, also biological data are given on the two species of Molossus involved. These studies bear directly on the problem as found in the Southern United States and Puerto Rico, or wherever other species of house bats are involved.

ACKNOWLEDGMENTS

We gratefully acknowledge the encouragement given to us by the Government of Trinidad and Tobago, especially the Ministry of Agriculture, Lands and Fisheries; the Chief Technical Officer (Agriculture); and the Technical Officers of Research and Animal Health. We also thank the Bureau of Sport Fisheries and Wildlife for their initial suggestion and their willingness to consider our findings for publication. We take pleasure in expressing our gratitude to the householders who allowed us to conduct these experiments and to the occupants of house No. 8 who volunterred their house as the control. Special mention must be made of Mr. Camodin Boodoo and his staff for their valuable contribution.

We sincerely thank Mr. J. Newel Lewis, Dip. Arch., F.R.I.B.A., for reading the manuscript and clarifying architectural terminology.

Thanks are also extended to the senior author's wife, Elizabeth R. Greenhall, for editing the manuscript.

BIONOMICS AND CHEMICAL CONTROL OF FREE-TAILED HOUSE BATS (Mollossus) IN TRINIDAD

By Arthur M. Greenhall and Gerald Stell

The problem of bats infesting roof spaces in Trinidad could be described as ever-present and acute, especially since bat proofing is not the accepted practice. For the rest of this paper, reference to houses should be interpreted as the roof space, except where otherwise specified.

The majority of houses in Trinidad are occupied by bats soon after the house is constructed. In one known instance bats entered a newly built house before the human occupants took up residence, a matter of a few months after the roof was erected. To prevent bats entering houses, the ideal solution is to bat-proof properly in the first place, since bat-proofing afterwards may prove costly and sometimes is impracticable. The possibilities of using chemical means of eradicating and repelling bats already present in houses with the prospect of achieving a long residual effect had not been thoroughly explored in Trinidad and it was thought this might have practical value.

The reasons for keeping bats out of houses can be listed as follows:

(1) Psychological unpleasantness to human occupants.
(2) Damage to ceilings due to the accumulation of bat guano and urine which frequently results in the need to replace ceiling sheeting.
(3) The dried guano penetrates the cracks where the ceiling sheets are joined together and falls into the rooms below.
(4) The bat guano attracts cockroaches and other coprophagous insects.
(5) The possibilities that bats and insect fauna may be a human health hazard.

Several considerations are involved in human health. The inhalation of guano and chitinous dust which floats in the air can cause irritation. Recent findings by Emmons (1958) show that the fungus, Histoplasma capsulatum, causal agent of pulmonary histoplasmosis, has been associated with house bats in the U.S.A. and isolates have already been taken from various bat habitats in Trinidad. The rabies virus has been isolated from Molossus major, the most abundant species found in houses. Greenhall (1959) collected it in a house in Trinidad. Although only a few species of mites (Dermanyssidae and Myobiidae), dipteran bat flies (Streblidae) and hemipteran bugs (Polyctenidae) have been recorded as ectoparasites on the species of house bats mentioned below (Anon. 1958), attention is drawn to their possible health hazard by Scott (1958): "Bat Ectoparasites (ticks, mites and fleas) may attack man, particularly when bats are infesting a house."

DISTRIBUTION OF FREE-TAILED BATS (MOLOSSIDAE)

The Molossidae or free-tailed bats, all of which are insectivorous, occur in the tropical and subtropical regions of both hemispheres, with intrusions of two genera, Tadarida and Eumops, into the Southern United States.

Approximately a dozen genera of this family have been described with only five normally occurring in the Western Hemisphere. Four of these have so far been found in Trinidad: Tadarida, Molossops (Cynomops), Promops and Molossus. The first three, up to now, have not been observed roosting in buildings, but have been taken under leaves and in hollow tree branches. Members of the genus Molossus are usually found in buildings, though they are occasionally taken under palm leaves and in hollow trees. The reasons for this variation of habitat are not clear, as conditions under an enclosed, hot, galvanized iron roof are certainly very different from those found under an open palm leaf or in a hollow tree trunk. Nevertheless, it is man who has created the enticing artificial conditions for the bats and more often than not laymen disregard the beneficial contributions the bats make.

SPECIES AND ABUNDANCE OF MOLOSSUS

Only two species of bats were encountered in these experiments and both belong to the genus Molossus. The commonest species was the little free-tailed bat, Molossus major (Kerr), with 1,592 collected dead. This is also the most abundant species of bat frequenting roof spaces in Trinidad. The other species present was the greater free-tailed bat, Molossus rufus Geoffroy, with 339 collected.

SEX RATIOS

The sex ratio of both species was approximately 1:1 as recorded for *M. major* (784 males, 808 females), and for *M. rufus* (150 males and 189 females).

BREEDING CYCLES

Evidence was accumulated to indicate the following possible breeding cycle in *M. major*. Pregnant females were taken in June, July and August; single, very young bats and lactating females in July, August, September and October; and immature males and females in October. The gestation period is unknown for this species but these observations suggest that there is only one generation per year. From these and other observations on this species, it would appear that the young are not born before July. This is supported by data in Table V, which show a marked increase in the bat population for the period June to December, 1959. The same populations remained fairly static from January to June, 1959.

As shown above, the numbers of *M. rufus* were not sufficient to give a clear picture of its breeding cycle. However, pregnant females were taken in March, July, August and October; single, very young bats in July and October; and immature males in September, October and November. From these collections and other observations in Trinidad, it is possible that there may be two generations per year for this species.

OBSERVATIONS ON BAT BEHAVIOR

The bats were generally observed to have two avenues of entry, under the roof corrugations and through the louvres. During the day they rested in places most inaccessible to humans, such as under and between the rafters, also particularly close to the eaves, hiding in the corrugation spaces. After flight and during the night when the bats returned to the house, they usually clung to the supporting rafters and dropped their chewed-up insect food, feces and urine onto the ceiling sheets. They then crawled over the floor to their actual sleeping roosts. It is this movement which accounts for the bumping and thumping sounds usually mistaken for the presence of rats and mice. Thus it was important to place any chemical residue in such a position that crawling bats would pick it up on their fur where it could be ingested during the preening and grooming process and where the toxic fumes would serve as a repellent to the bats.

The males possess musk or scent glands (Figure 1) which are situated in the chest region and the secretion from these glands has a characteristic odor which penetrates the roost. It is thought that as these bats enter the house belly downwards and head first some of this secretion adheres to the surface of the point of entry and this provides an olfactory recognition for the species as well as for sex. These stains are easily visible from the ground and are useful in recognizing a house occupied by bats.

METHODS OF POPULATION ASSESSMENT

Routine inspections were made, varying from daily to monthly intervals, to collect the dead bats which resulted from insecticidal application and assessments were made of remaining live bats. This was attempted at first by endeavoring to: count individual bats inside the roof space; listen for squeaks and chirps which indicated pockets of non-visible bats; and distinguish between fresh guano after removing the old. However, the estimate of the bat population thus obtained was found to be highly inaccurate and a new method had to be devised. This consisted of the following procedure: Two observers with torchlights and tally counters were positioned outside at opposite ends of the house some distance from the building where they could see all sides and corners of the house (Figure 5) between the hours of approximately 6 - 7 p.m., depending on the time of sunset. By way of example (Table I) data taken from the fifth spraying experiment clearly show the discrepancy between the two techniques.

TABLE I

COMPARISON OF OLD AND NEW METHODS OF BAT POPULATION ASSESSMENT

House No.	Total bat population before spraying (old method)	Total bat population after spraying (new method) including dead bats recovered
7	44	52
1	10	63
9	52	143
3	50	94
6	24	49
2	20	23
5	60	128
	260	552

In actual fact, only about half the true bat population was accounted for by the old method. Furthermore, reference to Table II shows the consistency of the new method when observations over successive nights are compared in houses B and C.

POPULATION IN INDIVIDUAL HOUSES

From our population studies by the new method, it appeared evident that individual houses maintained numerically similar bat populations over the period of observation. A few examples are quoted (Table II) over specified periods of observation.

TABLE II

BAT POPULATIONS IN INDIVIDUAL HOUSES

	Number	Actual counts	Average	Periods of observation
	B	198;203;184	195	Over 5 days
	C	14;10;10	11	Over 5 days
	C	12;17;17;16	15	Over 3 weeks
	E	36;58;44;53	48	Over 4 weeks at weekly intervals
	E	45	45	After 3 months
(Control)	8	340;385;324	346	Over 6 months at 3 monthly intervals

These observations were all made from chemically untreated houses and show a wide range of bat population.

In order to prove that these bat populations are in fact separate and stable for each individual house, a detailed study of the population dynamics and a bat-banding or marking program would be necessary.

PREVIOUS STUDIES ON CONTROL METHODS

A certain amount of work has been done elsewhere where the same problem exists (Silver et al. 1935, 1951), but there the emphasis was mainly placed on the use of dangerous fumigants. These included the burning of sulphur or the evolution of hydrogen cyanide gas which are extremely hazardous not only to the operators but also to the house dwellers and in addition give only temporary relief, since there is no residual effect.

Less dangerous materials, such as naphthalene and paradichlorobenzene, have also been advocated, but on test in Trinidad were found to vaporize too rapidly due to the high temperatures and humidities prevailing on this island. For instance, roof space conditions were as follows for the period January 13-19, 1959: Maximum temperature of 104° F.; minimum temperature of 67° F.; humidity, 55-100%. Where the bats actually roost would in fact show, at times, greater daily extremes over a longer period, where temperature ranges from 60°-135° F. have been recorded in other investigations. This possible 75° fluctuation within a 24-hour period has caused metal roofs to contract and expand so that "bat proofing" plugs of wood, concrete, plaster, or other materials are rendered useless due to the cracks and spaces resulting from this exaggerated roof movement.

A number of local bat repellents have also been tried, such as hanging spiky lime twigs where bats congregate, burning dried pepper pods, erection of lights (both electric and kerosene) frequently used in combination with owl or hawk wings to produce moving shadows, and finally spreading out pineapple skins. These methods have all met with only partial or temporary success. Sticky and chemical bird repellents have also been advocated by Scott (1958).

Two specific examples of the use of insecticides may also be cited as they were tried out in Trinidad. BHC sprayed from high-volume pneumatic machines is reported by Robertson (1952) to have eliminated bats from houses and given a residual effect for one year. De la Motte (1958) has reported that dieldrin applied through a low-volume power-operated sprayer eliminated bats from cocoa drying sheds, though the bats then controlled would probably have been of different species from the normal house bats in Trinidad. A final reference came to our notice during the compilation of this paper when, although not advocating the wholesale destruction of bats, Eads (undated) claimed that 50% D.D.T. had been used with some success.

EXPERIMENTAL SITE

The experimental site was located at the Central Experiment Station, Cocoa Board, and the Eastern Caribbean Farm Institute for the following reasons: The bat problem had been apparent for a number of years; the houses are uniformly constructed to a standard plan; the occupants, who are scientists, appreciated the problem and were willing to cooperate; and the necessary equipment, materials and labor were readily at hand.

EXPERIMENTAL LAYOUT AND TYPES OF HOUSES

For the main experiment the houses were distributed as shown on the plan (Figure 4) and consisted of eleven two-storied, L-shaped buildings, each of approximately 1,410 square feet roof space within walls and covered with corrugated asbestos-cement sheets (Figure 3). The floors of the roof spaces, which are also the ceilings of the rooms below, consisted of pressboard fixed together by thin wooden strips. A set of wooden louvres was situated at each end of the L and at the right angle of the L. There was also a trap door at each end of the L, or in some cases there was only one situated at the end of the longest side. One house was selected as a control, which remained untreated throughout the trial period. Other houses were selected for experimentation at a later date and these are described separately.

Obviously, the total number of experimental houses (in the same location and of similar construction) is too small to permit valid statistical projection.

MATERIALS AND METHODS OF APPLICATION

It was decided to use the four generally available chlorinated hydrocarbon insecticides, B.H.C., D.D.T., chlordane, and dieldrin, in various formulations, at different concentrations and applied in several ways: by smoke generators, hand-operated high-volume pneumatic sprayers, power-driven high-volume sprayers, low volume power driven sprayers or mist blowers, and power-driven dusters. Miscellaneous equipment used included aluminum expansion and step ladders, rubber torchlights, vacuum cleaner, brushes and dust pans for removing bat guano, asbestos plates for safe support of the smoke generators, polythene bags for transporting dead bats to the laboratory, measuring bucket and scales for preparing spray mixture, protective clothing and face masks for spraying purposes, counting aids for recording bat populations, thermohydrograph, etc.

Internal spraying was extremely difficult and sometimes impossible due to the following conditions: There was very little working space between the roof and the ceiling, making it impossible for a person to stand and sometimes even to enter; the risk to the operator of slipping off joists connecting the pressboard and falling through the ceiling; extremely high temperatures, over 100° F.; inaccessibility of areas where the roof meets the ceiling and corners as well as the high points at the gable ends; and hazard to the operator due to the toxic nature of the chemicals.

However, outside application under the corrugations was considered to be impractical because of the height of the buildings, the high winds experienced and the unsightly appearance left on the walls after spraying, although in one instance this was the only possible method. In practice, power-operated low-volume spraying or dusting was the easiest and safest to apply when the operator could discharge the insecticide in the form of an air-assisted blast away from himself, which would penetrate to all parts of the roof space. This was done by either placing the nozzle through the trap door at each end when it was not necessary even to enter the roof space, or if there was only one entrance present, by operating the machine from the middle of the L towards the blind end and then from the trap door as in the first method.

Unfortunately, the residue of the low-volume spray was not what was desired and after dusting by the same machines and smoke generation all failed to give the required deposit, a high-volume method of application had to be adopted. Hand-operated machines of the knapsack type proved too cumbersome for this purpose and eventually a hose line from a high-volume power-operated spraying machine proved satisfactory (Figure 2). The operator could move this from one end of the L to the other with ease and without discomfort from the spray fumes. A further refinement was possible by the high-volume method in that the spray could be seen to penetrate the corrugated and louvred openings, serving as a useful guide to adequate application and also placing a deposit of the insecticide where it was most needed. It will be shown later how important the method of application is when the results are assessed. It might also be added that although the smoke generators were ignited with due consideration being given to wind direction and trap door exit, they were still found to be most hazardous under these conditions.

PRINCIPAL INVESTIGATIONS

Ten houses were treated and one remained untreated as the control in the main insecticide experiment. Choice of materials, quantities and dilutions were selected on a comparable cost basis and are shown in the tables relating to each experiment. Water was the only diluent used.

TABLE III

1st BAT EXPERIMENT AT CENTRAL EXPERIMENT STATION - 1958

House Number	Treatments	Number of dead bats collected: During 1st Week	During 2nd Week	During 3rd Week	During 4th Week	Total dead bats
1	B.H.C. (20% Emulsible concentrate); dilution ratio 1:25	7	1	1	0	9
9	B.H.C. (20% E.C.) 1:50	39	0	2	0	41
2.	Dieldrin (20% E.C.) 1:25	10	13	4	4	31
10	Dieldrin (20% E.C.) 1:12.5	24	18	4	1	47
3	D.D.T. (50% Wettable paste) 2 lbs.	5	19	5	15	44
7	D.D.T. (50% W.P.) 4 lbs.	7	26	39	12	84
5	Chlordane (74% E.C.) 1:50	3	4	2	0	9
6	Chlordane (74% E.C.) 1:25	16	17	4	2	39
4	B.H.C. Smoke Generator	6	3	0	1	10
11	B.H.C. (50% Wettable Powder) 4 lbs.	3	0	0	0	3
8	CONTROL					

TABLE IV

5th BAT EXPERIMENT AT CENTRAL EXPERIMENT STATION - 1958

House Number	Bats dead prior to 1st Week	Treatments	Number of dead bats collected: 1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th-12th Week	12-Week Total	Bats flying at end of period
7	10	D.D.T. (50% W.P.) 12 lbs.	26	6	0	4	2	0	1	1	40	12
1	48	B.H.C. (50% W.P.) 12 lbs.	17	7	0	6	0	0	1	0	31	32
9	59	B.H.C. 12 lbs.	85	6	1	0	1	0	0	2	95	49
3	85	D.D.T.+ B.H.C. 6+6 lbs.	61	23	10	0	0	0	0	0	94	0
6	42	D.D.T.+B.H.C. 6+6 lbs.	25	11	5	0	2	0	0	2	45	4
2	117	D.D.T.+B.H.C. 12+12 lbs.	19	2	0	0	0	0	0	0	21	2
5	12	D.D.T.+B.H.C. 12+12 lbs.	96	9	7	6	0	0	0	0	118	10

RESULTS

The first experiment (Table III) involved the low-volume spraying of eight houses, numbers 1, 2, 3, 5, 6, 7, 9, & 10, also the hand-operated high-volume spraying of house number 11, using four gallons of liquid per house, and the liberation of 48 B.H.C. smoke generators, "Gammexane No. 22", in house number 4, over the period March 17-19, 1958. House number 8 was the control.

D.D.T. and dieldrin proved to be the most toxic, which fact was later confirmed at the end of the nine-month trial period when this particular mortality was found to represent approximately one-third of the total bat populations inhabiting the houses treated by these two insecticides. On the other hand, only one-fifth of the population was killed by the chlordane treatment and one-sixth by B.H.C. For reasons of cost and human safety in application it was decided to continue with D.D.T. only as a killing agent, experimenting with other formulations of B.H.C. mainly as a repelling agent, as it had been noticed that this insecticide had the immediate effect of causing bats to fly out of the house. Also, this was more desirable as these bats are insectivorous and are considered biologically useful.

Houses for the following series of experiments were initially chosen in order of lack of success and in general the most successfully treated houses were left as long as possible. Also, whenever it was practical the same successive chemical was used, that is, of course, limiting our choice to D.D.T. and B.H.C.

The next experiment took place on July 15, 1958, and consisted of the low-volume spraying of houses 1 & 2 with the same quantity of liquid per house, but at four times the previous lowest dosage of B.H.C. wettable powder and D.D.T. wettable paste respectively. However, even with the increased dosage, the kill by low-volume spraying was about the same, although still outstandingly better with D.D.T., and its residual effect lasted about two months.

A third experiment consisted of the power-operated dusting of houses 9 & 10, on July 22, 1958, with B.H.C. in the form of 50% wettable powder and 5% dust. Dusting had little effect and in actual fact collection of dead bats was discontinued in house number 10 after ten days, and another treatment was tried.

A fourth experiment followed on August 7, 1958, when the power-operated high-volume spraying of houses 4, 10 & 11 was carried out. Twelve gallons of liquid per house were used, composed of D.D.T. 50%

wettable powder, B.H.C. 50% wettable powder and D.D.T. 50% wettable paste, at the rate of one pound per gallon of water, respectively. The mortality rate was found to be much higher and extremely rapid by this new method, using D.D.T., and was most effective when used as a wettable powder.

A fifth and final experiment in this main series was carried out on October 4-8, 1958 (Table IV), using the same high-volume method but with the addition of combinations of D.D.T. and B.H.C. as well as the separate use of these materials. It was at this juncture that the improved method of counting bats flying out at night was devised, as described earlier under "Methods of Population Assessment."

It will be observed that where the previous eradication of bats was high, the subsequent kill was reduced. However, results point to the need for making an accurate assessment of the bat population in each house before spraying is begun. The combined spray apparently gave no more convincing results.

FOLLOW-UP

In addition to the seven houses checked for bat population in the final spraying experiment, which was terminated in December, 1958, the other four houses were also checked at the same time. Further checks were made in the months of March, June and December, 1959, and March, 1960, again of all houses, including the untreated one, and the results were compared (Table V).

TABLE V

SUMMARY OF ALL BAT EXPERIMENTS AT CENTRAL EXPERIMENT STATION, 1958/59

House Number	Total number dead bats (up-to-date)	Total number of live bats flying outside				
		Dec. '58	Mar. '59	June '59	Dec. '59	Mar.'60
1	79	32	17	16	40	38
9	153	49	38	23	109	80
10	73	16	6	0	86	82
3	179	0 (bat proofed since Dec.)	0	0	0	0
4	294	95	33	29	41	43
7	150	12	0	0	13	0
11	135	26	2	0	2	3
2	138	2	6	1	4	3
5	130	10	2	1	0	0
6	67	4	10	0	0	0
8 (control)	-	340	385	324	545	476

In the majority of cases, bat populations diminished during the first six months following the final spraying. On the other hand, the population of the control house remained about the same during the first six months increasing in the last six months, as also occurred in the unsuccessfully treated houses. Bats were almost completely eliminated from seven out of the ten sprayed houses, while six of these remained comparatively free of bats for more than a year and the remaining one for six months. The reasons for three houses retaining some population and then building up again during the breeding period have been attributed to the less residual B.H.C. treatment which also was not so effective in large roof spaces. It is interesting to note that the most successfully treated houses were sprayed with either D.D.T. alone or mixed with B.H.C. The apparent lack of success in house number 4 with D. D. T. is explained by the incomplete application of the insecticide, as this was the first house sprayed by the new technique.

OTHER INVESTIGATIONS

To test the effectiveness of the sprays and the method of application used in experiments 4 and 5, houses not previously sprayed and of contrasting structure were chosen in the immediate vicinity for experimentation.

COCOA BOARD EXPERIMENTS

House A, of 2,456 sq. ft., about one mile east of house number 1 and of very different design, being a single story building with very spacious roof space, was sprayed with D.D.T. 50% wettable powder at the low rate on November 5, 1958. Once again the slow but effective killing action of this insecticide was demonstrated. A total of 375 bats were destroyed in four weeks with over half of these dying in the first week and more than a third in the second.

Houses B and C, about half a mile east of house number 1 and of identical construction to house A were checked for bat populations, at which time house B had an average number of 195 bats and house C had an average of 11 bats.

On inquiring into the history of previous human occupants of house C, it was discovered that several applications of aldrin insecticide, closely related chemically to dieldrin, had been made in the past and could account for the low bat population. It was, therefore, decided to spray house B only, when the following results were obtained from the application of a mixture of D.D.T. and B.H.C. at the low rate on February 3, 1959 (Table VI).

TABLE VI

2nd BAT EXPERIMENT AT THE COCOA BOARD, LA REUNION, 1959

Date of observations	Feb. 4	Feb. 6	Feb. 12	Feb. 17	Feb. 25
Live bats flying after spraying	129	117	11	17	1
Dead bats after spraying	0	10	56	10	0

In a period of just over three weeks the population of flying bats fell from 195 to 1, and 76 dead bats were recovered. From these figures it would appear that about 61% of the bats were repelled and about 39% killed. The untreated house C retained a steady population of about 15 bats over the same observation period and did not absorb many of the migrants from house B. A check carried out one year later revealed no reinfestation of house B.

EASTERN CARIBBEAN FARM INSTITUTE EXPERIMENT

A final experiment was carried out on two houses, D and E, about one-quarter mile west of house number 11. These houses were again of a different construction, long, rectangular and two storied, but with only about four inches of space between the roof and the ceiling sheets, demanding a different spraying technique. The objective here was essentially to rid the roof space of bats and, as there was no means of removing the dead bodies, to prevent bats dying in situ. Application had to be made from the outside through ventilation holes located on either side of the longest walls of the house (Figure 2). Almost twice the volume of liquid was needed and it was decided to use B.H.C. at the low rate. The houses had similar bat populations before spraying and only one of them was treated; namely, house D, on the 10th of March, 1959 (Table VII). The bats were successfully eradicated in three to four weeks and house D has remained free of bats for almost one year.

TABLE VII

BAT EXPERIMENT AT THE

EASTERN CARIBBEAN FARM INSTITUTE, 1959

	Number of bats flying outside							
	Before spraying	After 1 week	After 2 weeks	After 4 weeks	After 4 months	After 6 months	After 10 months	After 13 months
House D	34	8	8	0	0	0	0	0
House E	36	58	44	53	45	81	88	88

CONCLUSIONS

1. In Trinidad, the adoption of the corrugated roof has provided a suitable habitat for free-tailed bats, Molossus.

2. As a result of this artificial situation, house bats now constitute a serious nuisance problem in Trinidad from both health and economic aspects.

3. Although serious consideration should always be given to the bat proofing of a building during its initial construction, measures for eradicating house bats from a building already infested as well as methods for bat proofing after construction still play an important role.

4. A method for bat population assessment based on recording numbers flying out of the house in the evening gave consistent results and proved much more accurate than an internal count during the day.

5. The main points of access for the bats entering and leaving the roof spaces of the houses under experiment were the roof corrugations and openings between the louvres, although the little free-tailed bat, Molossus major, can pass through cracks as small as one-quarter inch.

6. Only two species of house bats were recorded, both insectivorous. Over four-fifths of the entire population consisted of the little

free-tailed bat, *Molossus major*, and less than one-fifth of the greater free-tailed bat, *Molossus rufus*. Both had approximately 1:1 sex ratios.

7. There was evidence that *M. major* has only one breeding cycle per year and some indication that *M. rufus* may produce two generations annually.

8. Application of a chlorinated hydrocarbon insecticide inside the enclosed roof spaces can be extremely difficult or even impractical both from a physical and a safety standpoint. The method finally adopted was conditioned by the space available, toxicity of the chemical used and the production of a suitable residue.

9. A satisfactory method for applying insecticides in the form of wettable powders or pastes has been outlined for particular types of houses. Basically, this consisted of a conventional high-volume, power-driven sprayer with hose line and jet long enough to reach the side of the roof space furtherest from the escape trap door.

10. For successful eradication of house bats, it is essential that the application be thoroughly carried out with no avenues for entrance or exit left unsprayed.

11. D.D.T. acted more as a toxicant and B.H.C. more as a repellent to bats.

12. Based on factors of economy and human safety, and also with a view to retaining as far as possible the beneficial attributes of these bats, the following repellent spray (rather than a toxicant) is recommended for bat control, especially in small, inaccessible roof spaces: one pound of B.H.C. 50% wettable powder to one gallon of water. However, where it is advisable to exterminate the bats, especially in large roof spaces, the substitution of D.D.T. for B.H.C. at the same dosage rate is preferred.

13. If the spraying has been successfully carried out, the population of live bats can be expected to fall to zero by the end of three to four weeks from the application of either of these treatments.

14. Information on the residual effectiveness of these insecticides is not complete but a period of at least one year is indicated with D.D.T. in large roof spaces and there is every possibility that it may be effective for a longer period. B.H.C. is less residual, but in small roof spaces may be effective up to one year.

15. As each building presents its own bat problem, due to diverse methods of construction, species of bat and locality, any method,

chemical or otherwise, for eliminating bats from roof spaces must always be designed specially for that particular building. For example, recent observations by the senior author on the British Guiana and Brazilian border have shown that free-tailed bats will also live under galvanized roofs and between parts of the roof structure where there is no ceiling.

16. The house bat problem presents a challenge not only to the biologist and public health worker, but also to the architect and builder.

CAUTION

IT IS STRONGLY RECOMMENDED THAT DEAD OR MORIBUND BATS WHEREVER FOUND, AS A RESULT OF THESE METHODS, SHOULD NEVER BE PICKED UP BY THE BARE HAND as they may be infected with rabies or some other ailment which may be dangerous to humans, and/or contaminated with an insecticidal residue which may also be dangerous to humans.

REFERENCES

Anon., Report of Trinidad Regional Virus Laboratory. A Five-Year Summary, 1958.

De la Motte, D. Y. M., Private communication, 1958.

Eads, Richard B., "Bats", Texas State Department of Health, 1 p.

Emmons, C. W., "Association of Bats with Histoplasmosis", Public Health Reports, Public Health Service, U. S. Department of Health, Education and Welfare, Vol. 73, No. 7, pp. 590-595, July 1958.

Greenhall, A. M., "The Ecological Role of Trinidad Bats, Especially the Vampire and Bat Rabies", The Veterinary Record, Vol. 71, No. 10, pp. 188-190, March 1959.

Robertson, A. Maxwell, "Benzenehexachloride in Bat Control", A private communication to T. Geddes Grant Ltd., Trinidad, April 1952.

Scott, H. G., "Bats, Public Health Importance and Control", A Communicable Disease Center Training Leaflet, Public Health Service, U. S. Department of Health, Education and Welfare, Atlanta, Georgia, 1958.

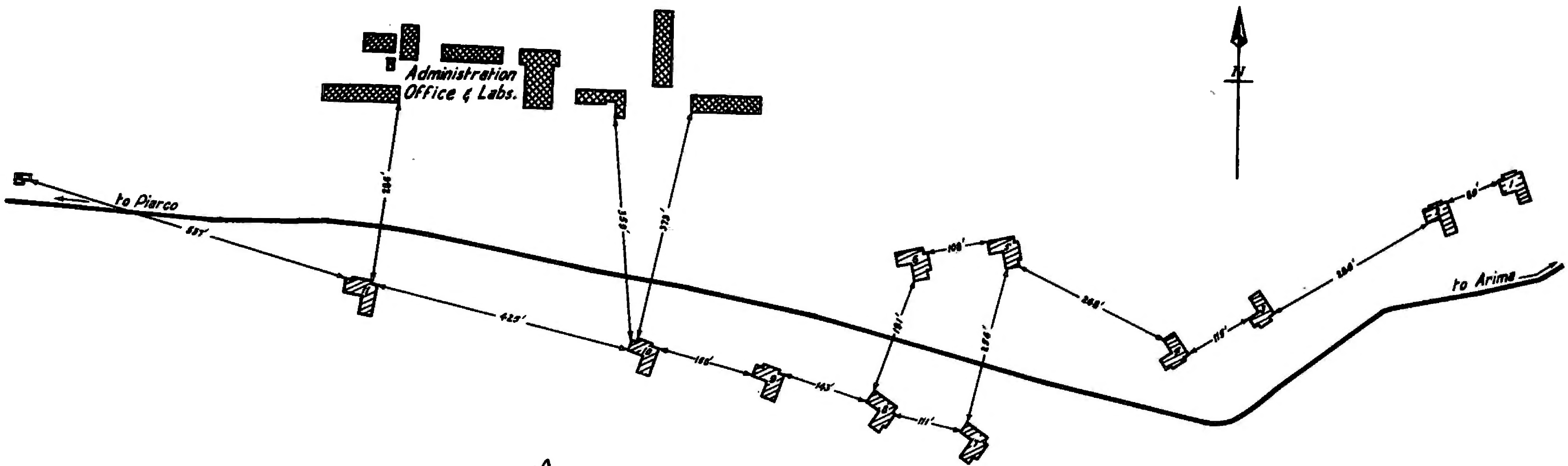
Silver, J., "Eliminating Bats from Buildings", U.S.D.A. Leaflet No. 109, pp. 1-4, 1935.

Silver, J. and Jones, J. C.,"Control of Bats", Wildlife Leaflet No. 333, Fish and Wildlife Service, U. S. Department of the Interior, pp. 1-4, January 1951.

Figure 1. Greater Free-tailed Bat *Molossus rufus rufus*, male, ventral view, showing musk gland on chest. (Photo by Trinidad Regional Virus Laboratory)

Figure 2. High volume, power operated spraying equipment with hose line. Note roof ventilation holes above window. (Photo by A. M. Greenhall)

Figure 3. Typical experimental house showing louvres and corrugated roofing. (Photo by Gerald Stell)



p-19

Figure 4. Plan of Houses at the Central Experiment Station.

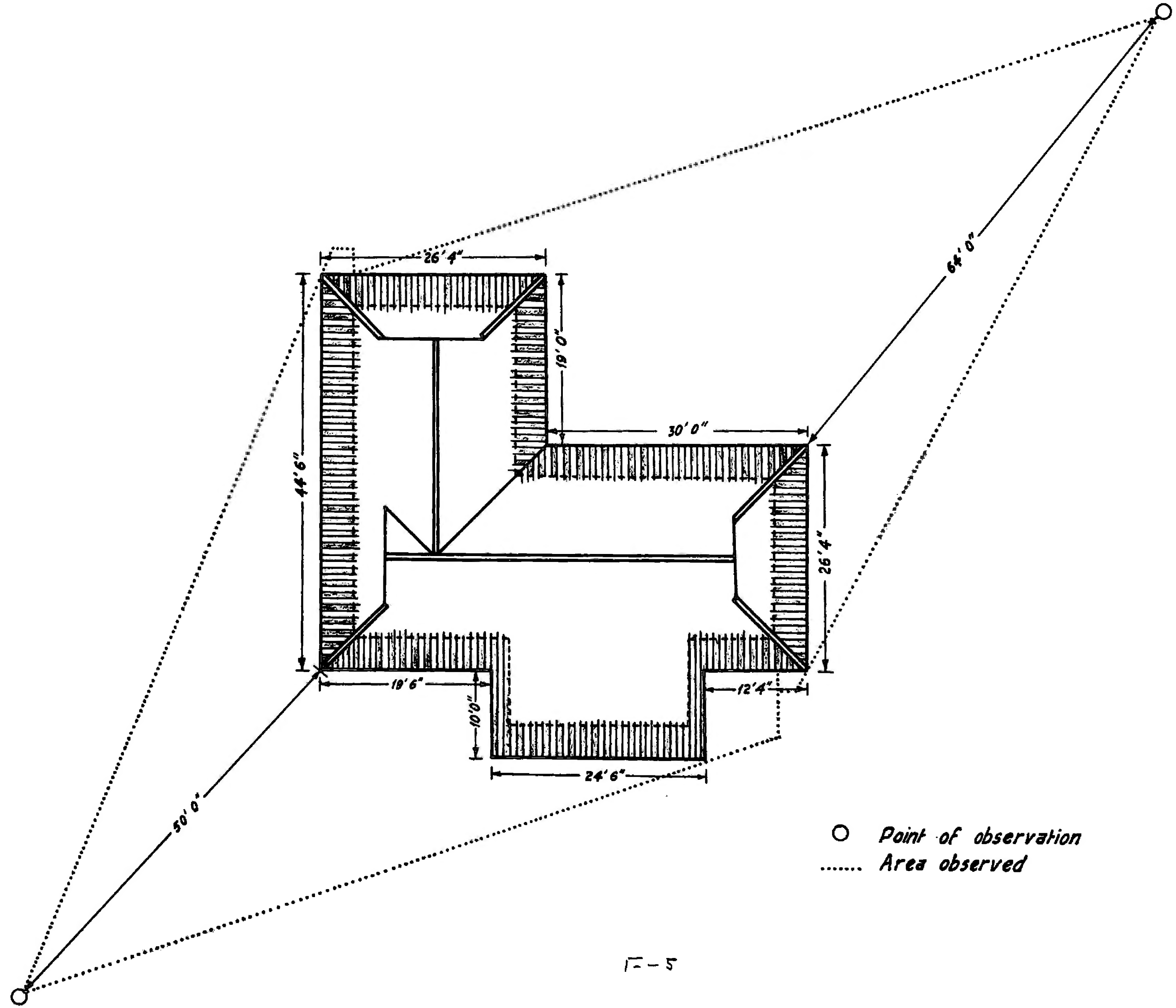


Figure 5. Observation locations used in recording bat flights from a typical dwelling.